the LV distribution side after at the output of the existing PDU transformers **121**. The combination of line reactor L_M **202** and line reactors Ls **204** reduce extra harmonic current in comparison to FIG. **1** and provides passive filtering.

[0048] FIG. **4** illustrates a typical configuration of a 3-phase PDU transformer. The PDU transformer includes a primary side **410** having windings **411-413** in a delta configuration and a secondary side **420** having windings **421-423** in a wye configuration with a neutral connection **427**. As shown, the primary side **410** and the secondary side **420** are electrically isolated from each other **316**.

[0049] FIG. **5** shows both a PDU transformer **500** and a separate line reactor L_S module **500** having line reactors **501-503** to reduce current harmonics. This configuration is expensive and occupies extra IT space or volume as it contains two discrete magnetic circuits.

[0050] FIG. **6** shows a magnetically coupled PDU transformer **600** with added values of line impedance using leakage inductance coils **601-603** in one modular frame. The leakage inductance coils **601-603** are formed by additional windings coupled to the respective windings **421-423** and incorporated into the same package as the windings **421-423**.

[0051] FIG. **7** shows a multi-level MVUPS electrical system incorporating the PDU transformer **600** of FIG. **6** according to embodiments of the present disclosure. Appropriate values of line impedance may be obtained by adjusting allowable values of leakage inductances of the PDU transformers **600** to reduce line current harmonics. There are no separate line reactor components in addition to the respective PDU transformers **600**. Hence, the electrical system **700** reduces both size and overall cost. As shown, the electrical system **700** uses a passive filtering configuration.

[0052] FIG. **8** shows an electrical system **800** having a line reactor L_M **202** located at the MV supply line. The electrical system **800** uses a transformerless medium voltage uninterruptible power supply (MVUPS) **300** including a multi-level inverter **302** and an LCL filter. The electrical system **800** also uses LV active filtering (AF) for the IT server assembly **120** coupled to the secondary coils of the PDU transformer. Thus, the electrical system **800** incorporates hybrid filtering including both MV passive and LV active filtering.

[0053] The active filters **802** may include another energy storage device, e.g., the energy storage device **1602** of FIG. **16**, such as an ultracapacitor, a battery, or a combination of the battery and the ultracapacitor, a two-level inverter, e.g., the two-level inverter **1606** of FIG. **16**, and LCL filters, e.g., the LCL filters **1608** of FIG. **16**, to provide harmonic current to compensate for the harmonic current drawn by the nonlinear electrical components of the IT server assembly **120** and the mechanical cooling equipment **125-128**. In embodiments, the other energy storage device of the active filter **802** is coupled in parallel with the two-level inverter, and the two-level inverter is coupled in series with the LCL filters. The two-level inverter is controlled by a digital signal processor. The advantage of using an active filter is that it does not introduce a voltage drop like the passive line reactor does.

[0054] FIG. **9** shows an electrical system **900** incorporating a transformerless MV DCSTATCOM. The electrical system includes the DC-DC converter **133**, the multi-level inverter **302**, LCL filter **310**, and a controller **935** coupled to the DC-DC converter **133** and the multi-level inverter **302** located at the medium voltage utility/grid side **910**. The controller **935** generates space vector pulse width modulation (SVPWM) signals and operates the multi-level inverter **302** using the SVPWM signals. The controller **935** also operates the DC-DC converter **133** and the multi-level inverter **302** in Active Filtering and MVUPS operation modes. In embodiments, the MVUPS mode is enabled during an interruption in power. The electrical system also includes, at the load side **920**, existing PDU transformers **121** and line reactors **204** coupled to the secondary side of the PDU transformers **121**. Thus, the electrical system **900** incorporates hybrid filtering including MV active filtering and LV passive filtering.

[0055] The control circuits for active filtering analyze and determine the harmonic components of the current with respect to the fundamental component of the current (e.g., all or a portion of the harmonic components within the range of the second harmonic component to the thirty-fifth harmonic component) delivered to the load and inject opposite harmonic currents to mitigate the overall line harmonics current. To determine the harmonic components of the current, a current sensor **825** of the electrical systems of FIGS. **8** and **11** senses a current at a location between the active filters **802** and the IT server assemblies **120** and/or a current sensor **925** of the electrical systems of FIGS. **9-11** senses a current at a location between the PCC and the transfer switch **114**, and the current is filtered by a high-pass filter to obtain the harmonic components of the current with respect to the fundamental component of the current. The active filtering can achieve minimum current harmonic distortion levels. The cost to implement active filtering is high because of the use of power electronics devices, e.g., the multi-level inverter **302**, and the DSP devices, e.g., the controller **935**, used to control the power electronics devices.

[0056] Thus, the electrical system may be designed to obtain a minimum or a reasonable amount of harmonic current reductions for any particular application so that the implementation costs are minimized or are at a reasonable level. For example, the cost of the AF to reduce the overall current harmonics to 15% is less than the cost of the AF to reduce the overall current harmonics to 5% as the AF to reduce the overall current harmonics to 15% needs to inject less harmonic current into the electrical system to cancel harmonic current at that level.

[0057] In the AF mode, simultaneous independent active (P) power compensation and reactive (Q) power compensation is achieved by controlling the phase angle δ between the voltage of the multi-level inverter **302** V_{INV} and the voltage of the grid V_{GRID}, and the modulation index (m) to obtain variable V_{INV}, according to the following equations:

$$P=3*V_{GRID}*V_{INV}*\sin\delta/\omega*L \tag{1}$$

$$Q=3*V_{GRID}*(V_{INV}*\cos\delta-V_{GRID})/\omega*L \tag{2}$$

where ω is the line frequency and L is the effective line reactance of the LCL filters. The active (P) power compensation portion supplies the harmonic current by operating the switching devices, e.g., IGBTs, of the multi-level inverter **302** to compensate for the harmonic component of the current from the nonlinear load. The reactive (Q) power compensation portion maintains the power factor at PCC. The phase angle δ is controlled to be a positive value to supply harmonic current in the case of AF mode and/or fundamental current in the case of MVUPS during an interruption in power from the MV utility supply **111**. The phase angle determines harmonic current to compensate for